

NEW SPECIES AND RECORDS OF *CULICOIDES* REARED FROM
ARBOREAL HABITATS IN PANAMA, WITH A SYNOPSIS OF
THE *DEBILIPALPIS* GROUP
(DIPTERA: CERATOPOGONIDAE)

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Abstract.—A study was made of the breeding sites of *Culicoides* in Panama with special attention to plants of the family Bromeliaceae as larval habitats. Collections were made between May and August 1976 at a field station on an island in the reservoir formed behind the newly constructed Bayano River dam. *Culicoides* adults were successfully reared from larvae and pupae collected in bromeliads of the genera *Aechmea* and *Vriesea*, tree holes, rotting palm stumps, and moist trapped leaf humus on tree trunks at or near ground level. Although 82 bromeliads in five genera were sampled, *Culicoides* was reared only from *Aechmea* and *Vriesea*, whose large water tanks proved a better habitat during rainless weather. Five species of *Culicoides* were reared from these habitats, including three new species, *C. annuliductus*, *C. bayano*, and *C. filiductus*. The pupae of the three new species are described and illustrated. A key is presented for the identification of 27 Neotropical species of the *debilipalpis* group to which these species belong.

Bloodsucking midges of the genus *Culicoides* Latreille are important pests of man and domestic animals and are known to feed on many wild vertebrate species. The role of *Culicoides* midges as disease vectors is just now beginning to be appreciated through their implication in the transmission of several viruses of the bluetongue group to cattle, sheep, and various wild bovine and antelope species and their transmission of filarial worms of the genera *Acanthocheilonema*, *Dipetalonema*, *Macacananema*, *Mansonella*, and *Onchocerca*, and haematozoa of the genera *Haemoproteus*, *Hepatocystis*,

and *Leucocytozoon*. Pinheiro et al. (1976) isolated the virus of Oropouche fever, a human pathogen in Brazil, from *Culicoides* pools containing 95% *C. paraensis* (Goeldi). Several viruses, still being studied as potential human pathogens, have recently been isolated by Gorgas Memorial Laboratory workers from *Culicoides* collected in the Bayano region of Panama. For these reasons it was highly desirable to undertake a detailed study of possible breeding sites of the *Culicoides* species in the Bayano River area, both for an understanding of the possible significance of these species in disease transmission, and to aid in devising eventual control measures should such be required.

The larval biology of Neotropical *Culicoides*, while receiving considerable study, remains for the most part unknown. Earlier observations of larval habitats in Panama include those of Carpenter (1951), Woke (1954), Breeland (1960), and Wirth et al. (1968). Wirth and Blanton (1959) described known breeding sites for only 15 of the 88 reported Panamanian species of *Culicoides*, some of which have a biology closely associated with the local flora, in which the immature stages are found in plants, plant products, or the rainwater associated with them. *Culicoides* were reported from crab holes, salt marshes, tree holes, rotting calabash, bromeliads, mangrove swamps, and inflorescences of *Heliconia*. Williams (1964) made a significant contribution to Neotropical *Culicoides* breeding biology, reporting larval habitats for 24 species in Trinidad. New habitats for *Culicoides* from that study included "decaying cocoa pods, discarded animal bedding of macerated coconut fibers, mouths of rivers which enter the sea across open sandy beaches where salt and fresh water mix to flood large sandy areas at each high tide; the decaying flowers of Cachibou (*Calathea lutea*), and the rotting flowers of Scotch Attorney (*Clusea rosea*).\" Williams (1964) and Aitken et al. (1975) reported *C. nigrigenus* Wirth and Blanton from the bromeliad *Guzmania* sp. in Trinidad. Clastrier (1971) reared *C. quasiparaensis* Clastrier from moss growing on a palm trunk and from moist material accumulated in the axils of palm fronds in French Guiana. Fish and Soria (1978) collected an undescribed species of *Culicoides* in Bahia, Brazil, from water held in the flower bracts of *Calathea* sp. (Marantaceae).

During May–August 1976 an investigation of *Culicoides* breeding places was undertaken at the field station of the Gorgas Memorial Laboratory on Majé Island in the Bayano River impoundment about 120 km east of Panama City, Republic of Panama. This period ordinarily forms a part of the wet season, but it was unusually dry in 1976 with very little rain, and consequently suitable larval habitats were difficult to find.

Bromeliads were collected by hand with care to preserve water-filled "tanks" formed by the leaf bases. Plants collected from sites higher than 5 m were tied closed and lowered by rope. Biological data recorded included site description, height from ground, accessibility of light, tank size, water

content, and presence of debris or animal life. Plant specimens were dissected in white enamel pans while washing each leaf with collected rain-water. Tank contents were examined carefully for *Culicoides* larvae and pupae, which, if found, were placed individually in small cotton-stoppered test tubes with ca. 5 ml of water and debris from the bromeliad; the tubes were checked daily for pupation and emergence of adults. The remaining sample was transferred from the pan to 500 ml paper cartons which were covered with fine nylon mesh. These were also examined daily. All emerging arthropods were collected and stored individually in vials of 70% alcohol for later identification. Having two rearing methods allowed for individual association of larval skin and pupal case with a specific adult specimen while also permitting emergence of larger numbers of adults from the less-disturbed, nutrient-containing original sample.

Other habitats sampled were tree holes, water-containing bamboo internodes placed previously by Gorgas workers for mosquito larva collection, moist soil and leaf debris areas, rotting palm stumps, stream sources, *Heliconia* (Musaceae) inflorescences, palm crowns, inflorescences of *Costus* (Costaceae), leaf axils of *Xanthosoma* (Araceae), and a water-holding palm frond. These were chosen as potential habitats for *Culicoides* immatures on the basis of water and moisture content or by previous reports as known habitats. These sites were sampled by collecting substrate into 500 ml carton containers using a white enamel dipper, a basin, or suction tube. In most cases, habitats were not depleted or destroyed on sampling to permit sequential collections as the wet season progressed.

RESULTS

A total of 169 collection sites were sampled, including 82 bromeliads, 23 tree holes, 21 bamboo internodes, 18 moist soil and leaf debris areas, 9 rotting palm stumps, 7 stream sources, 3 *Heliconia* inflorescences, 3 palm crowns, 1 *Costus* inflorescence, 1 leaf axil of *Xanthosoma*, and 1 water-holding palm frond. The 23 tree hole sites were sampled 53 times during the collection period and the 9 rotting palm stumps 12 times, bringing the total number of habitat samples to 202. The bromeliads comprised *Aechmea pubescens* Baker, *Billbergia macrolepis* L. B. Smith, *Guzmania erythrolepis* Brongniart ex Planchon, *G. lingulata* var. *flammea* (L. B. Smith) L. B. Smith, *Tillandsia anceps* Loddiges, *T. elongata* (Baker) L. B. Smith, *T. fasciculata* var. *fasciculata* Swartz, *T. monadelphica* (E. Morren) Baker, and *Vriesea heliconioides* var. *heliconioides* (Humboldt, Bonpland, and Kunth). From these collections 363 *Culicoides* larvae and 41 live pupae were isolated to produce 256 adults. *Culicoides* larvae were found in tree holes, *Aechmea* and *Vriesea* bromeliads, leaf humus, rotting palm stumps, streams, bamboo internodes, and *Heliconia* inflorescences, but adults were successfully reared from only the first four.

Table 1. Numbers of various collections from bromeliads. Te = *Tillandsia elongata*; Tf = *T. fasciculata*; Ta = *T. anceps*; Tm = *T. monadelpha*; Ap = *Aechmea pubescens*; Vh = *Vriesea heliconioides*; Gl = *Guzmania lingulata*; Ge = *G. erythrolepis*; Bm = *Billbergia macrolepis*; u = unidentified bromeliads.

	Bromeliad species									
	Te	Tf	Ta	Tm	Ap	Vh	Gl	Ge	Bm	u
Total collections	6	4	1	4	19	39	1	3	1	4
Collections with free standing water	6	4	1	4	11	36	1	3	1	4
Height above ground in meters; avg./range	2.4/ 1-4	2.4/ 1.5-3	6	ground	4.6/ 0-9	3.6/ 5-7	3	2.4/ 2-3	1	3.0/ 2-5
<i>Culicoides</i> adults reared					9	5				
Plants with <i>Culicoides bayano</i>					2	3				
Plants with <i>Culicoides paraensis</i>					1					
Ceratopogonidae adults other than <i>Culicoides</i>					7	24				
Culicidae adults	1	2			34	39				
Psychodidae adults					3	25				
Tipulidae adults					1	42		4		

Of the nine species of bromeliads collected, *Culicoides* were reared only from *Aechmea pubescens* and *Vriesea heliconioides*. These two species were the most abundant bromeliads in the area, and their tank structure was such that they consistently contained plenty of free water; they probably provided year round breeding opportunities. The other bromeliads were neither as abundant nor as wet, and the lack of *Culicoides* rearings from them could be explained on either basis. During the progression of the wet season bromeliads and other plants were found to contain more water. The tree holes were excellent *Culicoides* habitats because, regardless of architecture of individual holes or their height above ground, they were more permanent and not so profoundly depleted by lack of rain, exposure to the sun, or proximity to the forest canopy.

It should be stressed that the breeding strategies of the *Culicoides* comprising this study on the Pacific side of Panama are adapted to an area with a definite wet and dry season cycle. In the wetter tropical rain forests of the Atlantic side the *Culicoides* species would be expected to adapt their strategies to more constant rainfall and occasional excesses possibly detrimental to their optimum survival.

The study demonstrates the taxonomic importance of including data on rearing methods in the collection of *Culicoides*. Eighty-one percent of the specimens reared represented three previously undescribed species belonging to a difficult taxonomic group where the association of sexes by reared material was critical to understanding the species. The described methods of individual isolation and rearing proved to be quite effective and minimally time-consuming.

Culicoides adults were identified by one of us (WWW) as belonging to five different species, all taxonomically related within the *debilipalpis* group (see Wirth and Blanton, 1959, 1974): *C. debilipalpis* Lutz, *C. paraensis* (Goeldi), and the three new species herein described. Whereas the five species could easily be distinguished in the adult stage, the pupae were practically indistinguishable and larval identification was impossible.

Linley and Kettle (1964) gave excellent descriptions and figures of the larva and pupa of *C. hoffmani* Fox, which to date is the only member of the *debilipalpis* group whose immature stages have been studied. We recommend a close study of their paper before and while using the pupal descriptions of our new species. Our descriptions of the adults follow closely the format and use the characters explained and illustrated in the papers by Blanton and Wirth (1979) and Wirth and Blanton (1959, 1974).

The holotypes of the new species are deposited in the U.S. National Museum of Natural History, Washington, D.C. Paratypes as available will be deposited in the British Museum (Natural History), London; Gorgas Memorial Laboratory, Panama, R.P.; Museu de Zoologia da Universidade de São Paulo, Brazil; and Museum National d'Histoire Naturelle, Paris.

The classification of the Neotropical species of the *debilipalpis* group is difficult and progress has been slow in revising, redescribing, and illustrating the previously named species. Aitken et al. (1975, Trinidad), and Wirth and Blanton (1959, Panama; 1973, Amazon; 1974, West Indies) have published fairly satisfactory keys of the *Culicoides* of particular regions, but no inclusive key has been published for the identification of all members of this very difficult group. While not quite complete, and although it still has some weak couplets and species that need more study, the following key is presented in the hope that future identifications will be easier.

KEY TO SPECIES OF THE *CULICOIDES DEBILIPALPIS* GROUP

- 1. Second radial cell included in a very dark spot; cell R5 with 3 or 4 small pale spots, the 2 poststigmatic pale spots sometimes fused; subapical pale spot in cell R5 usually transverse, not attaining wing margin; cell M2 with only 1 pale spot distal to level of mediocubital fork; 2 functional spermathecae present; antennal sensory pattern 3, 8–10 (sometimes also on some of segments 4–7) (*debilipalpis* Group) 2

- Without the above combination of characters other groups of *Culicoides*
- 2. Cell M1 with 3 pale spots 3
- Cell M1 with 1 or 2 pale spots 6
- 3. Pale spot present in cell M2 lying adjacent to anterior side of midportion of mediocubital stem (Fig. 3c); smaller spermatheca with long threadlike duct (Fig. 3d); sclerotized ring of duct short and cylindrical; eyes narrowly separated; wing with marginal pale spots large and distinct *fliductus*, new species
- No pale spot in cell M2 lying adjacent to midportion of mediocubital stem; smaller spermatheca with duct broader, not threadlike; sclerotized ring, eye separation, and wing spots various 4
- 4. Smaller spermatheca with duct more slender and tapering than that on the large one; sclerotized ring elongate and tapering; eyes broadly separated; wing with marginal spots smaller and usually not meeting wing margin; male parameres slender in midportion with elongate ventral lobe *paraensis* (Goeldi)
- Smaller spermatheca with duct as stout as that on large one, not tapering; sclerotized ring short and cylindrical; eyes usually narrowly separated; male parameres without elongate ventral lobe 5
- 5. Antennal sensory pattern 3,7-10; male paramere with definite, broad, ventral swelling *neoparaensis* Tavares and Sousa
- Antennal sensory pattern 3,8-10; male paramere uniformly slender in midportion, without ventral swelling *quasiparaensis* Clastrier
- 6. Cell M1 with 1 pale spot near tip of cell *trilineatus* Fox (in part)
- Cell M1 with 2 pale spots 7
- 7. Anal cell with 2 pale spots in distal portion; crossvein r-m with pale spot small and lying entirely on distal side of vein *mirsaе* Ortiz
- Anal cell with 1 pale spot in distal portion; crossvein r-m with pale spot centered on the vein 8
- 8. Mesonotum with prominent pattern of punctiform brown dots; 3 small round equidistant pale spots in a triangle in cell R5; (halter knob dark at base; eyes bare; antennal segments in continuous series) *ginesi* Ortiz
- Mesonotum with prominent pattern of large pale patches or without prominent pattern 9
- 9. Palpus pale yellow; small species, wing 0.65 mm long; antennal segment 11 shorter than 10; (male genitalia with stem of paramere gradually tapering to fine tip, no ventral lobe or distal fringing spines) *gabaldoni* Ortiz

- Palpus not pale yellow; larger species, wing 0.7–1.4 mm long; antennal segment 11 subequal to or longer than 10 10
- 10. Second radial cell unusually broad; (pale spot at end of costa well separated from spot behind 2nd radial cell, farther from it than from the distal pale spot in cell R5, which is narrow and transverse; distal pale spot in anal cell elongated, extending caudad nearly to wing margin; eyes bare; halter brown; larger species, wing 1.00 mm long; aedeagus with slender distal process bearing deep distal fork *glabrior* Macfie
 - Second radial cell not unusually broad 11
- 11. Pale spot absent in front of mediocubital fork 12
 - Pale spot present in front of mediocubital fork, though sometimes faint 25
- 12. Pale spot absent behind medial fork; (palpal pit opening by smaller pore) *horticola* Lutz
 - Pale spot present behind medial fork 13
- 13. Posterior poststigmatic pale spot located slightly distad of anterior one; (palpal pit broad and shallow; male aedeagus with broad truncate tip; parameres with stem slightly sinuate with lateral fringing spines, no ventral lobe) *imitator* Ortiz
 - Posterior poststigmatic pale spots oblique with posterior one located proximad of the other 14
- 14. Pale spot present in cell M2 lying adjacent to midportion of mediocubital stem; 3rd palpal segment long and slender with sensory pit deeper than diameter of pore opening; femora dark to tips; male apicolateral processes short, mesal notch between them on tergum 9; parameres sinuate and slender without ventral lobe; aedeagus short with simple tip *todatangae* Wirth and Blanton
 - No pale spot present in cell M2 lying adjacent to midportion of mediocubital stem 15
- 15. Distal pale spot in cell M1 extending to wing margin 16
 - Distal pale spot in cell M1 lying far from wing margin 17
- 16. Poststigmatic pale spots in cell R5 fused into a single pale spot; antennal sensory pattern 3,7–10 *eldridgei* Wirth and Barreto
 - Poststigmatic pale spots in cell R5 separate; antennal sensory pattern 3,8–10 *limonensis* Ortiz and Leon
- 17. Larger species, wing 1.08 mm long; 3rd palpal segment slender with broad shallow pit; aedeagus conspicuously cleft distad with 2 sharp laterally directed teeth on each side; parameres with simple twisted tips without fringing spines *crucifer* Clastrier

- Smaller species, wing less than 1.00 mm long; 3rd palpal segment and male aedeagus and parameres various 18
- 18. Wing densely hairy, with macrotrichia extending in at least 2 rows to base of cell M2 19
 - Wing moderately hairy, with macrotrichia only on distal ½ or less, a few in anal cell, hairs extending to base of cell M2 only in *C. bayano* 21
- 19. Wing length 0.80 mm; 3rd palpal segment long and slender, with pore opening smaller than pit diameter; eyes broadly separated, hairy; spermathecae brownish, ducts not annulate, sclerotized ring longer; aedeagus Y-shaped, with slender simple tip and slender, nearly straight basal arms; parameres with nearly straight stem and long ventral lobe; ventral root of basistyle moderately long and slender *debilipalpis* Lutz
 - Wing length 0.93–0.97 mm; eyes narrowly separated, bare; palpus, spermathecae and male genitalia various 20
- 20. Third palpal segment short and broad (PR 1.9) with moderately shallow pit, pore opening as large as pit diameter; proboscis short, P/H ratio 0.60; spermathecae nearly colorless, bases of ducts with fine annulations; male basistyle with ventral root long and slender, toes nearly meeting mesad; distomedian process of aedeagus short and stout with broad truncate tip; parameres sinuate without distinct ventral lobe *annuliductus*, new species
 - Third palpal segment moderately long and slender (PR 2.6), with moderately deep sensory pit, pore opening as large as pit diameter; proboscis long, P/H ratio 0.83; spermathecae brownish, bases of ducts not annulate; male basistyle with ventral root short and stout, the toe blunt-pointed; aedeagus with long slender distomedian process, apex deeply divided into 2 sharp appressed points; parameres curved gently in midportion and tapering to slender, filamentous tip *trilineatus* Fox (in part)
- 21. Antennal sensory pattern 3,7–10; 3rd palpal segment with small deep pit *germanus* Macfie
 - Antennal sensory pattern 3,8–10; 3rd palpal segment various 22
- 22. Eyes narrowly separated; 3rd palpal segment with moderately broad shallow pit; male aedeagus as in *debilipalpis* (couplet 19); parameres slender and sinuate without ventral lobe *denisae* Clastrier
 - Eyes moderately to broadly separated; 3rd palpal segment various; male aedeagus short, tip broad with distinct median lobe and sharp lateral points 23
- 23. Female eyes broadly separated; male paramere with distinct ventral lobe *eadsii* Wirth and Blanton

- Female eyes moderately separated; male paramere without ventral lobe 24
- 24. Female wing without macrotrichia in base of cell M2; 4th palpal segment usually as broad as long; male aedeagus unusually broad at tip, the lateral points prominent; heel of ventral root much shorter than toe *hoffmani* Fox
 - Female wing with macrotrichia extending in 2 rows to base of cell M2; 4th palpal segment longer than broad; male aedeagus only slightly broadened at tip, the lateral points inconspicuous; heel and toe of ventral root blunt and long *bayano*, new species
- 25. Pale spot present in cell M2 lying adjacent to anterior side of midportion of mediocubital stem; 3rd palpal segment with sensory pit deeper than diameter of pore opening; eyes broadly separated *insinuatus* Ortiz and Leon
 - No pale spot present in cell M2 lying adjacent to midportion of mediocubital stem 26
- 26. Third palpal segment with small deep pit; smaller species, wing 0.72 mm long; halter infuscated; aedeagus with short tapering, distally rounded, distal processes; paramere sinuate without ventral lobe, with distal fringing spines; palpal pit with pore opening smaller than pit diameter *spurius* Wirth and Blanton
 - Third palpal segment with broad shallow pit 27
- 27. All femora with subapical pale bands; (3rd palpal segment with broad elliptical pit *equatoriensis* Barbosa
 - Femora dark to tip 28
- 28. Antennal sensory pattern 3,8-10; 3rd palpal segment with shallow pit with same size pore; wing length 0.86 mm *darlingtonae* Wirth and Blanton
 - Antennal sensory pattern 3,(5),6-10; 3rd palpal segment with pit deeper, opening by a smaller pore; wing length 0.91 mm *youngi* Wirth and Barreto

Culicoides debilipalpis Lutz

Culicoides debilipalpis Lutz, 1913: 60 (♀; Brazil; fig. wing); Wirth and Blanton, 1959: 442 (redescribed; figs.; Panama); Blanton and Wirth, 1979:78 (redescribed; figs.; Florida; review of biology and distribution).

Distribution.—A common species in the southeastern U.S. from Maryland and Kentucky to Florida and Louisiana; absent in Texas, Mexico, and the West Indies; present in Central and South America south to Argentina. It is replaced in Texas and Mexico by *C. eadsi* Wirth and Blanton and in the West Indies by *C. hoffmani* Fox.

Biology.—Williams (1964) reared this species from rotting cacao pods

and bamboo stumps in Trinidad; Messersmith (1964) reared it from wet tree cavity debris in Virginia; and Smith (1965) reared it from wet tree holes and stump holes in Florida.

New records.—PANAMA: Panama Prov., Bayano Field Sta., June 1976, G. C. Vitale, 1 ♂, 5 ♀ reared from a collection of very wet soil trapped on a split fallen tree trunk at 10 cm above ground level; 1 ♀ reared from a tree hole at 1.5 m.

Culicoides annuliductus Wirth, NEW SPECIES

Fig. 1

Female.—Wing length, 0.97 mm; breadth, 0.47 mm.

Head: Eyes (Fig. 1e) narrowly separated, bare. Antenna (Fig. 1a) with lengths of flagellar segments in proportion of 28-26-30-30-30-30-30-32-32-32-48, antennal ratio 0.77; sensory pattern 3,8-10, segments 8-10 each with 4 sensilla coeloconica. Palpus (Fig. 1b) with 3rd segment rather short and swollen, with moderately shallow sensory pit with opening same diameter as pit; palpal ratio 1.9. Proboscis short, P/H ratio 0.60; mandible with 14-15 teeth.

Thorax: Brown; mesonotum with moderately prominent dark brown sublateral patches. Legs (Fig. 1i) brownish, knee spots blackish; narrow pale rings subapically on fore- and midfemora and basally on all tibiae, broad apex of hindtibia pale; tibial comb with 4 spines, the 2nd from the spur longest. Wing (Fig. 1c) deeply infuscated with distinct small round pale spots as figured; 2nd radial cell dark to tip; 2 poststigmatic pale spots in cell R5 well separated, the posterior one very slightly proximad of the other; distal pale spot in cell R5 transversely oval to slightly irregular in shape; cell M1 with 2 pale spots, the distal one lying far from wing margin; cell M2 with small oval pale spot behind medial fork and a larger round one near wing margin; cell M4 with round pale spot in midportion not meeting wing margin; anal cell with one pale spot in distal portion; macrotrichia numerous and coarse, extending to base of cell M2 in more or less a double row; costal ratio 0.59. Halter with dark brown knob.

Abdomen: Brown. Genital sclerotization as in Fig. 1d. Spermathecae (Fig. 1f) 2, poorly sclerotized and yellowish brown; sclerotized ring and rudimentary $\frac{1}{3}$ as in figure, the ring short and tapering; functional spermathecae ovoid, the slender necks bearing distinct microscopic annulations; slightly unequal, measuring 0.058 by 0.039 mm and 0.051 by 0.035 mm including the necks.

Male.—Similar to female with usual sexual differences; antenna with well developed brownish plume, segments 3-12 more or less fused; segments 3,10-12 with sensilla coeloconica; last 4 segments with lengths in proportion of 5-13-10-11. Genitalia (Fig. 1h): 9th sternum with broad shallow caudo-median excavation, ventral membrane not spiculate; 9th tergum long and

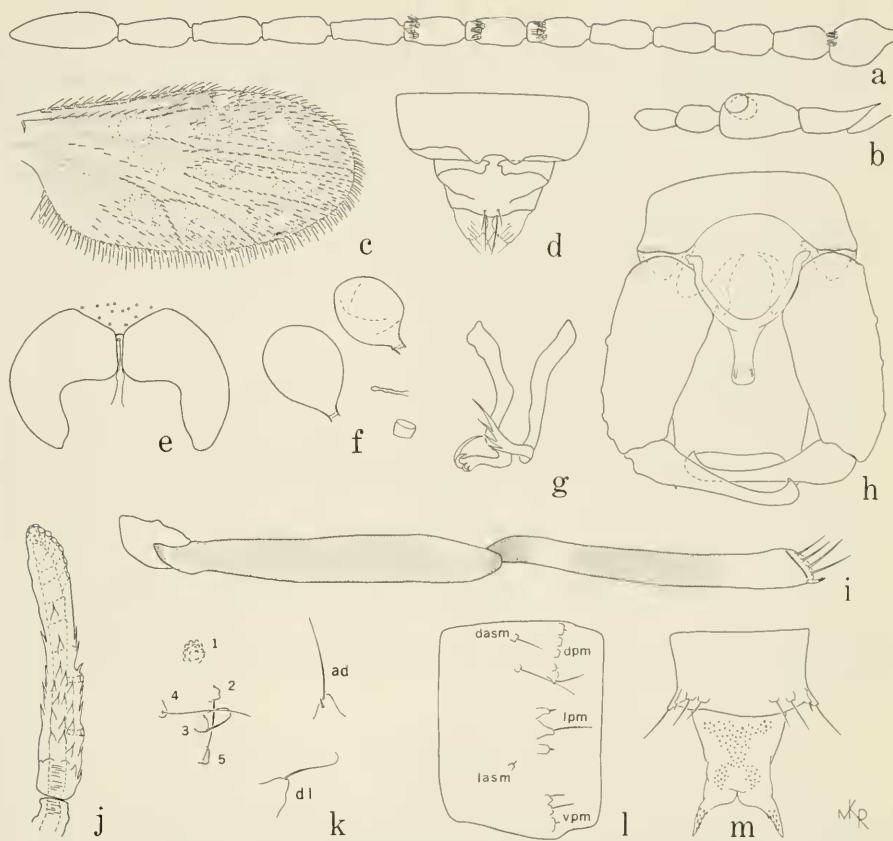


Fig. 1. *Culicoides annuliductus*. a-f, i, female; g-h, male; j-m, pupa. a, Antenna. b, Palpus. c, Wing. d, Genital sclerotization. e, Eye separation. f, Spermathecae. g, Parameres. h, Genitalia, parameres removed. i, Hindfemur and tibia. j, Respiratory horn. k, Thoracic tubercles 1 to 5 (left), and anterodorsal (top right) and dorsolateral (bottom right) tubercles of head. l, Lateral view of 4th abdominal segment. m, Dorsal view of last 2 abdominal segments.

tapering with moderately long, triangular, apicolateral processes. Basistyle with foot-shaped ventral root, anterior "toes" unusually long and slender, nearly meeting each other on midline; dististyle slender and slightly curved, with bent, hooked tip. Aedeagus with basal arch extending to $\frac{1}{2}$ of total length, basal arms slender and curved; distomedian process short and stout with broad truncate tip. Parameres (Fig. 1g) separate; each with knobbed base, stem slightly bent near base, slender and slightly sinuate in midportion, without ventral lobe; distal portion not greatly elongated, with slender pointed tip and 3-4 lateral fringing spines.

Pupa.—Length 2.0 mm. Color of exuviae pale yellowish. Nearly identical

with pupa of *C. hoffmani* described by Linley and Kettle (1964). Respiratory horn (Fig. 1j) with 10 distal and 2 lateral spiracular openings; surface with coarse sharp scalelike spines on proximal $\frac{1}{2}$. Operculum lost on available specimens. Anterodorsal and dorsolateral tubercles of head as in Fig. 1k; thoracic tubercles as figured, no. 1 in form of a cluster of minute granules, 2, 3, and 4 with rather elongate setae, 5 unarmed. Head and thorax without distinct integumental spinules; abdomen without integumental spinules except dorsally on last segment as figured (Fig. 1m); segmental tubercles of abdomen as in Fig. 1l, lateral postero-marginals longer than in *C. hoffmani*. Apical processes of last segment with well-developed spinules and not as divergent as in *hoffmani* (Fig. 1m).

Distribution.—Known only from the type-series from Panama.

Types.—Holotype ♀, allotype ♂, Bayano Field Station, Panama Prov., Panama, June 1976, G. C. Vitale, reared from tree holes (type no. 76105, USNM). Paratypes, 36 ♀, 43 ♂, same data, all reared from tree holes. Of these, 67 were found in two tree holes from 1–2.5 m above ground level while the remaining 14 were found in three tree holes at heights of 8–9 m.

Discussion.—The species takes its name from the annulate ducts of the spermathecae. It is closely related to *C. debilipalpis* Lutz, from which it can readily be separated by the characters given in the key. This species has been reared only from tree holes, at various heights from 1–9 m above ground level.

Culicoides bayano Wirth, NEW SPECIES

Fig. 2

Female.—Wing length, 0.85 mm; breadth, 0.40 mm.

Head: Eyes (Fig. 2e) narrowly separated, with short interfacetal hairs. Antenna (Fig. 2a) with lengths of flagellar segments in proportion of 26-23-26-27-27-28-29-30-30-32-32-32-50, antennal ratio 0.82; sensilla coeloconica on segments 3,8–10, double on 10, with long ringing setulae. Palpus (Fig. 2b) with lengths of segments in proportion of 10-27-40-17-15; 3rd segment moderately swollen, palpal ratio 2.0, with moderately large and deep sensory pit opening by same size pore. Proboscis moderately long, P/H ratio 0.82; mandible with 15 teeth.

Thorax: Dark brown; mesonotal pattern not determined in slide-mounted specimens. Legs (Fig. 2h) brown, knee spots blackish; narrow pale rings subapically on fore- and midfemora, basally on all tibiae, broad apex of hindtibia pale; tibial comb with 4 spines, the 2 nearest the spur longest, subequal. Wing (Fig. 2c) dark grayish, with distinct pattern as figured; 2nd radial cell dark to tip; pale spot over r-m crossvein extending broadly to costal margin; poststigmatic pale spots in cell R5 two, more or less fused in a transverse double spot, distal pale spot in cell R5 rounded, slightly transverse; 2 oval pale spots in cell M1, distal one lying far from wing margin;

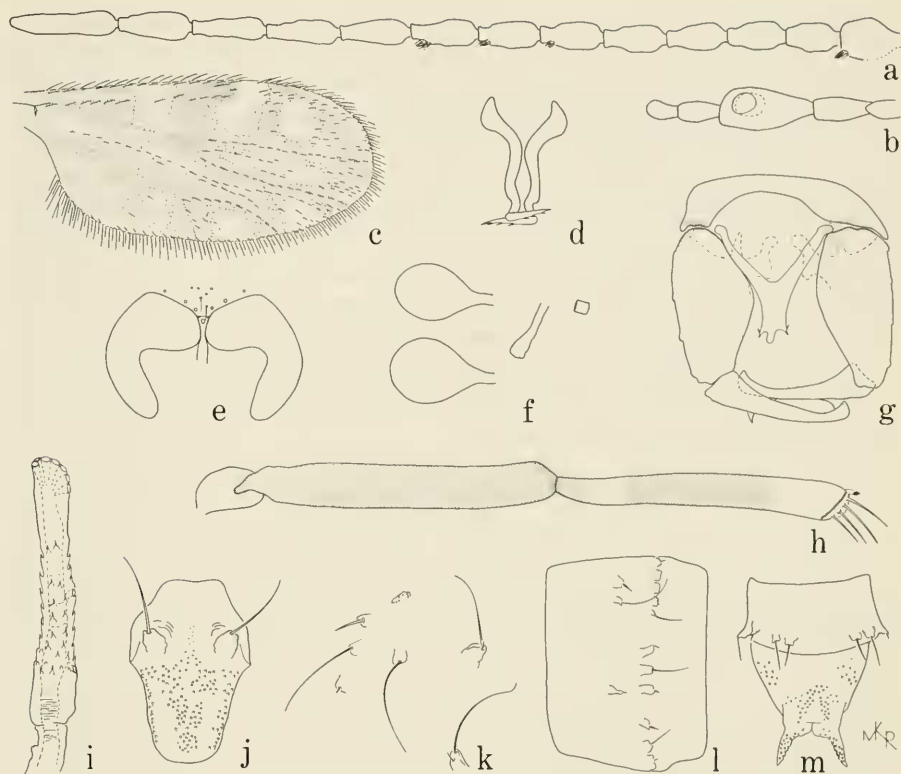


Fig. 2. *Culicoides bayano*. a-e, f, h, female; d, g, male; i-m, pupa. a, Antenna. b, Palpus. c, Wing. d, Parameres. e, Eye separation. f, Spermathecae. g, Genitalia, parameres removed. h, Hindfemur and tibia. i, Respiratory horn. j, Operculum. k, Tubercles of thoracic and head regions, as in Fig. 1k. l, Lateral view of 4th abdominal segment. m, Dorsal view of last 2 abdominal segments.

cell M2 with elongate pale spot behind medial fork and a rounded pale spot lying at wing margin in apex of cell; cell M4 with large rounded pale spot at wing margin; anal cell with 1 pale spot in distal portion. Macrotrichia sparse and inconspicuous, confined to distal $\frac{1}{2}$ of wing with a sparse double row extending to base of cell M2; costal ratio 0.58. Halter knob dark brown.

Abdomen: Brown. Spermathecae (Fig. 2f) 2, dark brown, ovoid with long slender necks; rudimentary spermatheca and sclerotized ring present, latter as broad as long with parallel sides; functional spermathecae slightly unequal, measuring 0.058 by 0.036 mm and 0.052 by 0.030 mm including necks.

Male.—Similar to female with usual sexual differences; antenna with sparse brownish plume, segments 4–12 more or less fused; segments 3, 10–

12 with sensilla coeloconica; last 4 segments with lengths in proportion of 17-55-41-50. Genitalia (Fig. 2g) short, nearly as broad as long. Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane bare; 9th tergum short and tapering with large triangular apicolateral processes. Basistyle with ventral root foot shaped, with "heel" and "toe" both blunt and stout and of approximately equal lengths; dististyle slender and nearly straight with hooked tip. Aedeagus with basal arch extending to $\frac{1}{2}$ of total length, basal arms stout and nearly straight; distomedian process moderately broad and stout, with apex well sclerotized and bearing a small rounded median process and 2 inconspicuous sharp lateral points, the latter each with a sharp, ventrally directed spine arising at base. Parameres (Fig. 2d) separate; each with basal knob slender and sinuate in midportion without ventral lobe; apex abruptly bent ventromesally and tapering to distal point with lateral fringe of 3-4 fine spines.

Pupa.—Length 1.9 mm. Color of exuviae yellowish brown, respiratory horns brownish. Very similar to that of *C. hoffmani*. Respiratory horn (Fig. 2i) with 7 distal and 2 lateral spiracular openings, surface with coarse scale-like spines on proximal 0.7. Operculum (Fig. 2j) similar to that of *hoffmani*, more fine, blunt spinules than in *hoffmani*; anteromarginal tubercles large, with long spine. Anterodorsal and ventrolateral tubercles (Fig. 2k, right) similar to those of *hoffmani*; dorsal tubercles of thorax similar to those of *annuliductus*, but tubercle 5 bearing a short seta as usual in the group. Integument of cephalothorax with abundant pale microtubercles and that of abdomen with numerous sharp micro-spines (similar to the "small scales" described by Linley and Kettle, 1964, in *C. hoffmani*). Segmental tubercles of abdomen as in Fig. 2l, nearly identical with those of *hoffmani* and *annuliductus*. Last segment (Fig. 2m) with apical processes short and directed caudad, slightly diverging, and bearing abundant spinules.

Distribution.—Panama.

Types.—Holotype ♀, allotype ♂, Bayano Field Station, Panama Prov., Panama, June 1976, G. C. Vitale, reared from *Aechmea pubescens* (type no. 76106, USNM). Paratypes, 20 ♂, 39 ♀, same data, except as follows: 27 from 6 tree holes, 19 from 3 rotting palm stumps, 6 from collections of leaf humus and moist soil trapped on a fallen tree trunk 1 m above ground level, and 13 from the bromeliads *Aechmea pubescens* and *Vriesea heliconioides*. Of the 65 reared adults, 50 came from sites 1-2.5 m above ground, 13 from bromeliads 3-5 m above ground, and 2 from tree holes more than 8 m above ground.

Other specimens examined.—PANAMA: Coco Solito, Canal Zone, 8 Dec. 1958, S. Breeland, in emergence cage 305, 2 ♂, 3 ♀; Mojinga Swamp, C.Z., 13 Oct. 1952, F. S. Blanton, light trap, 1 ♂; Fort Clayton, C.Z., 18 June 1952, F. S. Blanton, light trap, 1 ♂; Taboga Island, Panama Prov., 10 Dec. 1953, F. S. Blanton, light trap, 1 ♂.

Biology.—The Coco Solito specimens reared by Breeland were identified by Wirth as *C. hoffmani* and reported under this name by Breeland (1960) as follows: "Five specimens (2 males, 3 females) recovered from a single location in black muck mangrove habitat (type 1) with from 1 to 2 inches of standing water. Cage operated in position for a period of 6 cage weeks, Oct. 21, 1958 - December 5, 1958 near Rainbow City. *C. hoffmani* was recovered in this location to the exclusion of other species, although a subsequent study revealed no special habitat characteristics, except for standing water."

Discussion.—The species takes its name from the type-locality, the field station on the Bayano River in Panama Province, Panama. This species is very closely related to *C. hoffmani* but can be distinguished by the characters given in the key. The best characters are in the male genitalia, especially the shape of the ventral root of the basistyle and the distal processes of the aedeagus.

Culicoides paraensis (Goeldi)

Haematomyidium paraense Goeldi, 1905: 137 (♀; Brazil; fig. ♀, wing).

Culicoides paraensis (Goeldi); Lutz, 1913: 55 (combination; redescribed; figs.); Ortiz, 1951: 574 (redescribed; figs.; Venezuela); Wirth and Blanton, 1959: 440 (redescribed; figs.; Panama); Wirth and Blanton, 1974: 71 (redescribed; figs.; West Indies); Blanton and Wirth, 1979: 131 (redescribed; figs.; Florida; review of biology and distribution).

Distribution.—Common in North, Central, and South America and West Indies, in U.S. from Pennsylvania to Florida and Louisiana, Mexico and south to Argentina and Bolivia.

Biology.—Snow et al. (1957) and Smith (1965) found this species breeding in tree hole debris in Florida and Tennessee, Breeland (1960) reared it from tree hole debris in Panama, and Williams (1964) reared it from rotting cacao pods and a rotting calabash in Trinidad. Childers and Wingo (1968) reared it from sap flows from cottonwood trees in Missouri.

New records.—PANAMA: Bayano Field Station, Panama Prov., June 1976, G. C. Vitale, 3 ♂, 6 ♀ from 2 tree holes at 1.5 and 4 m above ground level; 1 ♀ from *Aechmea pubescens* at 5 m above the ground.

Culicoides filiductus Wirth, NEW SPECIES

Fig. 3

Female.—Wing length, 0.87 mm; breadth, 0.43 mm.

Head: Eyes (Fig. 3e) narrowly separated, hairy. Antenna (Fig. 3a) with lengths of flagellar segments in proportion of 35-23-26-30-28-28-28-28-28-28-30-45, antennal ratio 0.72; sensilla coeloconica present on segments 3, 8-10, 2 per segment, with long ringing setulae. Palpus (Fig. 3b) with lengths

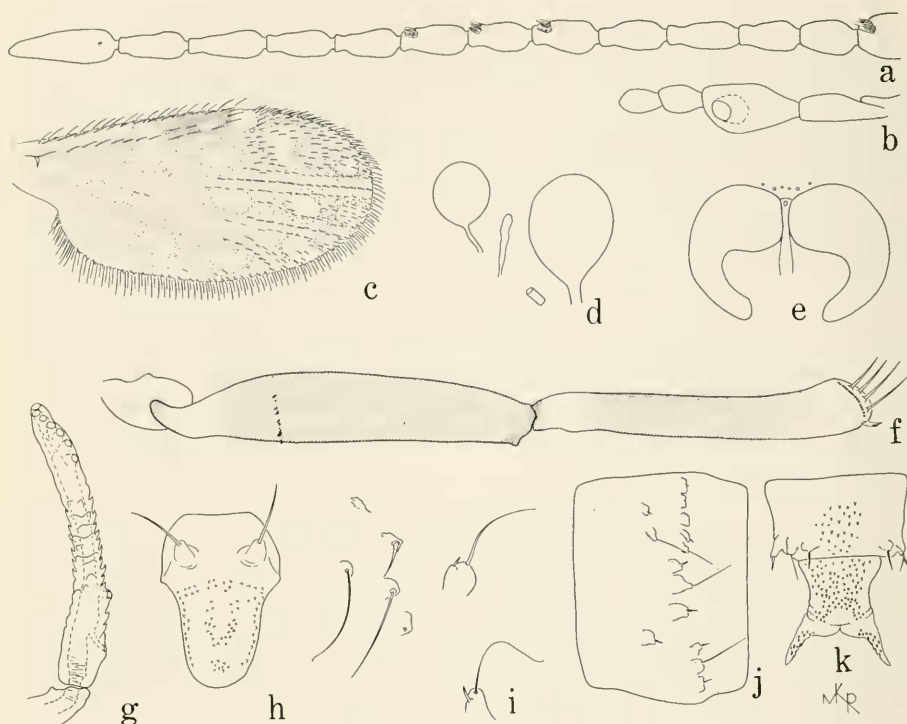


Fig. 3. *Culicoides fliductus*. a-f, female; g-k, pupa. a, Antenna. b, Palpus. c, Wing. d, Spermathecae. e, Eye separation. f, Hindfemur and tibia. g, Respiratory horn. h, Operculum: tubercles of thoracic and head regions, as in Fig. 1k. j, Lateral view of 4th abdominal segment. k, Dorsal view of last 2 abdominal segments.

of segments in proportion of 10-25-45-13-15; 3rd segment broad, palpal ratio 2.8, with large deep pit opening by a smaller pore. Proboscis short, P/H ratio 0.73; mandible with 15 teeth.

Thorax: Dark brown; mesonotal pattern not determined in slide-mounted specimens. Legs (Fig. 3f) brown, knee spots blackish; subapical pale rings on fore- and midfemora faint to absent, hindfemur entirely dark; tibiae with narrow basal pale rings, hindtibia with broad apex pale; tibial comb with 4 spines, 2nd from the spur longest. Wing (Fig. 3c) dark grayish with prominent, coarse macrotrichia; pattern as figured, 2nd radial cell dark to tip; pale spot over r-m crossvein continued in full width to costal margin; 2 well-separated small round poststigmatic pale spots in cell R5, the posterior one located slightly proximad; cell R5 with 2 pale spots in distal portion as in *C. paraensis*, the proximal one transversely V-shaped, the distal one quite small and round; cell M1 with 3 pale spots, the distal one located at wing margin; cell M2 with a distinct pale spot lying just ahead of

midportion of cubital stem, and an elongate pale spot lying behind medial fork and another lying ahead of mediocubital fork, and a large rounded pale spot at wing margin; cell M4 with round pale spot in midportion; anal cell with a round pale spot in distal portion. Macrotrichia sparse and confined to distal $\frac{1}{2}$ of wing; costal ratio 0.60. Halter knob dark brown.

Abdomen: Brown. Spermathecae (Fig. 3d) 2 plus vestigial 3rd and a slender tubelike sclerotized ring; functional spermathecae very unequal in size and shape; the larger ovoid with a long slender neck, measuring 0.063 by 0.044 mm including the neck; the smaller nearly spherical with a long threadlike neck 0.022 mm long, the main portion measuring 0.032 by 0.029 mm.

Male.—Unknown. Despite careful study no reared specimens could be attributed to this species and distinguished from *C. paraensis*, which was also present in the tree hole collections.

Pupa.—Length 1.8 mm. Color uniformly yellowish brown, respiratory horns darker towards tips. Nearly indistinguishable from pupae of *C. hoffmani*, *C. annuliductus*, and *C. bayano*. Respiratory horn (Fig. 3g) with 7 distal and 2 lateral spiracular openings. Operculum (Fig. 3h), tubercles of head and thorax (Fig. 3i), abdominal tubercles (Fig. 3j), and last 2 segments (Fig. 3k) as figured. Integument with abundant pale micro-tubercles and micro-spines resembling those of *C. hoffmani*, much better developed than those of *annuliductus* and *bayano*.

Distribution.—Panama.

Types.—Holotype ♀, Bayano Field Station, Panama Prov., Panama, June 1976, G. C. Vitale, reared from tree hole 1.5 m above ground (type no. 76107, USNM). Paratypes, 61 ♀, same data, of which 60 emerged from five tree holes while one emerged from a rotting palm stump. All specimens were from breeding sites less than 2.5 m above ground except one from a tree hole 8 m above the forest floor.

Other specimens examined.—PANAMA: Barro Colorado Island, C.Z., July 1967, W. W. Wirth, light trap, 6 ♀.

Discussion.—The species is named for the threadlike sclerotization of the neck of the subspherical small spermatheca. *Culicoides fliductus* belongs to a group of four Neotropical species including *C. paraensis* (Goeldi), *C. quasiparaensis* Clastrier, and *C. neoparaensis* Tavares and Sousa. These species have a wing pattern nearly identical with that of *C. debilipalpis* Lutz and related species, except for the presence of two extra pale spots located in the extreme apices of cells R5 and M1. The separation of these four species is detailed in the key.

ACKNOWLEDGMENTS

The senior author thanks W. G. Downs, Yale University School of Medicine, for advice and assistance throughout this study. He is also deeply

grateful to Pedro Galindo, erstwhile director of the Gorgas Memorial Laboratory, for advice, assistance, and the use of his facilities in Panama. He thanks Rudolfo Hinds, director of the Bayano Field Station, and Victor Herrera, who climbed all the highest trees for bromeliad collections. Thanks are also extended to Lyman B. Smith, Department of Botany, Smithsonian Institution, for identifications of the bromeliads. Financial support for the field study was provided through a Yale Summer Research Grant and a Yale International Travel Fellowship. We thank Robert E. Shope for his help in arranging the field study. We are grateful to Molly Ryan for preparation of the illustrations.

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